bottom. But when both the field and the rays are used the two streams diverge, each impinging upon the electrode nearest to it. The author proves that this is not due to any charge of the ammonium chloride particles, but to the fact that the free charges produced in the gas lead to a motion of ions towards the electrodes, and that the ions carry the gas and the vapour with them.

[Zeleny, *Phys. Rev.*, March, 1899.]

Magnetic Susceptibility of Water.—Doubt having been thrown upon the values for the magnetic susceptibility of water obtained by Jäger and Meyer, the same authors have made further determinations by two somewhat unusual methods. One of them consists in suspending a tube filled with water and closed at the bottom from one arm of a balance, and surrounding the lower end by a strong magnetic field. The susceptibility is, of course, negative, and so the force on the lower end of the water column is a push upwards, which diminishes the weight. The other method consists in measuring the velocity of efflux from such a tube. Under ordinary circumstances, the hydrostatic pressure alone drives out the water. In a magnetic field, a magnetic pull is superadded. This, in the case of water, is negative, and the efflux is correspondingly retarded. The calculations in both cases are surprisingly simple. The values obtained are $-0{\cdot}665 \times 10^{-6}$ by the first method, and $-0{\cdot}689 \times 10^{-6}$ by the second. The value previously obtained by the compensation method was $-0{\cdot}687 \times 10^{-6}$.

[Jäger and Meyer, *Wied. Ann.*, No. 3, 1899.]

PROF. D. E. HUGHES'S RESEARCHES IN WIRELESS TELEGRAPHY.

We have received from Prof. D. E. Hughes an abstract from a letter addressed to him by Mr. J. J. Fahie, together with his reply thereto, dealing with the early researches of Prof. Hughes on wireless signalling. The correspondence possesses far more than a passing interest for our readers, for it is directed to show that Prof. Hughes anticipated all other workers in this field of research, and can lay claim to have been the original discoverer of the phenomena upon which wireless telegraphy is effected, as well as to have applied these practically to a very considerable extent. We refer more particularly to this correspondence in our editorial notes :—

[copy.]

Extract from recent letter from Mr. J. J. Fahie to Prof. Hughes.

"Dear Prof. Hughes : I have now in the press a history of Wireless Telegraphy from 1838 to 1899, and in writing to Sir William Crookes for information he tells me that many years ago he saw some experiments of yours with the microphone, in which you signalled from one part of a house to another without connecting wires, and he desires me to refer to you for particulars. I think, with Sir William, that it is a pity you have not hitherto published your results, and I sincerely hope you will now do so. If also you would kindly favour me with a short account, I could find room for it in my book, which is now in the printer's hands.—Sincerely yours,

J. J. Fahie.

"Claremont Hill, St. Helier's, Jersey, April 26, 1899."

Prof. D. E. Hughes's Reply.

40, Langham-street, W., April 29, 1899.

Dear Sir : In reply to yours of the 26th inst., in which you say that Sir William Crookes has told you " that he saw some experiments of mine on aërial telegraphy, in about December, 1879, of which he thinks I ought to have published an account," and of which you ask for some information, I beg to reply with a few leading experiments that I made on this subject from 1879 up to 1886 :—

"In 1879, being engaged upon experiments with my microphone, together with my induction balance, I remarked that at some time I could not get a perfect balance in the induction balance, through apparent want of insulation in the coils, but investigation showed me that the real cause was some loose contact or microphonic joint excited in some portion of the circuit. I then applied the microphone in the circuit, and found that it gave a current or sound in the telephone receiver, no matter if the microphone was placed direct in the circuit, or placed independently at several feet distance from the coils, through which an intermittent current was passing. After numerous experiments, I found that the effect was entirely caused by the extra current, produced in the primary coil of the induction balance.

"Further researches proved that an interrupted current, in any coil, through which an electric current was sent, gave out at each interruption of the primary current, such intense extra currents, that the whole atmosphere in the room (or in several rooms distant) would have a momentary invisible change, which became evident if a microphonic joint was used as a receiver to a telephone. This led me to experiment upon the best form of a receiver for these invisible electric waves, which evidently permeated great distances, and through all apparent obstacles, such as walls, &c. I found that all microphonic contacts or joints were extremely sensitive. Those formed of a hard carbon such as coke, or a combination of a piece of coke resting upon a bright steel contact, were very sensitive and self-restoring ; whilst a loose contact between metals was equally sensitive, but would cohere, or remain in full contact, after the passage of an electric wave.

"The sensitiveness of these microphonic contacts in metals has since been rediscovered by Mons. Ed. Branly, of Paris, and by Prof. Oliver Lodge, in England, by whom the name of 'coherer' has been given to this organ of reception ; but, as we wish this organ to make a momentary contact and not cohere permanently, the name seems to me ill-suited for the instrument. The most sensitive and perfect receiver that I have yet made does not cohere permanently, but recovers its original state instantly, and, therefore, requires no tapping or mechanical aid to the separation of the contacts after momentarily being brought into close union.

"I soon found that, whilst an invisible spark would produce a thermo-electric current in the microphonic contacts (sufficient to be heard in the telephone in its circuit), it was far better and more powerful to use a feeble voltaic cell in the receiving circuit, the microphonic joint then acting as a relay, by increasing and diminishing the resistance at the contact, by the influence of the electric wave received through the atmosphere.

"I will not describe the numerous forms of the transmitter, and receiver, that I made in 1879, all of which I wrote down in several volumes of manuscripts in 1879 (but these have never been published), most of which can be seen here at my residence at any time ; but I will confine myself now to a few salient points. I found that very sudden electric impulses, whether given out to the atmosphere through the extra current from a coil, or from a frictional electric machine, equally affected the microphonic joint, the effect depending more on the sudden high potential effect than any prolonged action. Thus, a spark obtained by rubbing a piece of sealing-wax was equally as effective as a discharge from a Leyden jar battery of the same potential. The rubbed sealing-wax, or charged Leyden jar, had no effect, until they were discharged by a spark,—and it was evident that this spark, however feeble, acted upon the whole surrounding atmosphere in the form of waves, or invisible rays, of which I could not at the time determine. Hertz, however, by a series of original and masterly experiments, proved in 1887–9, that they were real waves similar to light, but of a lower frequency, though of the same velocity. In 1879, whilst making these experiments on aërial transmission, I had two different problems to solve : 1st, What was the true nature of these electric aërial waves, which seemed, whilst not visible, to spurn all idea of insulation, and to permeate all space to a distance undetermined. 2nd, To discover the best receiver that could act upon a telephone or telegraph instrument, so as to be able to utilize (when required) these waves for the transmission of messages. The second problem came easy to me, when I found that the microphone, which I had previously discovered in 1877–8, had alone the power of rendering these invisibl waves evident, either in a telephone or galvanometer, and up to the present time I do not know of anything approaching the sensitiveness of a microphonic joint as a receiver. Branly's tube, now used by Marconi, was described in my first Paper to the Royal Society (May 8, 1878), as the microphone tube, filled with loose filings of zinc and silver, and Prof. Lodge's coherer is an ordinary steel microphone, used for a different purpose from that in which I first described it.

"During the long continued experiments on this subject, between 1879 and 1886, many curious phenomena came out which would be too long to describe. I found that the effect of the extra current in a coil was not increased by having an iron core, as an electromagnet—the extra current was less rapid and, therefore, less effective. A similar effect of a delay was produced by Leyden jar discharges. The material of the contact breaker of the primary current had also a great effect. Thus, if the current was broken between two, or one piece of carbon, no effect could be perceived of aërial waves, even at short distances of a few feet. The extra current from a small coil, without iron, was as powerful as an intense spark from a secondary coil, and at that time my experiments seemed to be confined to the use of a single coil of my induction balance, charged by six Daniell cells. With higher battery power, the extra current invariably destroyed the insulation of the coils.

"In December, 1879, I invited several persons to see the results then obtained. Amongst others who called on me and saw my results were ;—

"December, 1879.—Mr. W. H. Preece, F.R.S.; Sir William Crookes, F.R.S.; Sir W. Robert Austen, F.R.S.; Prof. W. Gryll Adams, F.R.S.; Mr. W. Groves.

"February 20, 1880.—Mr. Spottiswoode, Pres.R.S.; Prof. Huxley, F.R.S.; Sir George Gabriel Stokes, F.R.S.

"November 7, 1888.—Prof. Dewar, F.R.S.; Mr. Lennox, Royal Institution.

"They all saw experiments upon aërial transmission, as already described, by means of the extra current produced from a small coil, and received upon a semi-metallic microphone, the results being heard upon a telephone in connection with the receiving microphone. The transmitter and receiver were in different rooms, about 60ft. apart. After trying successfully all distances allowed in my residence in Portland-street, my usual method was to put the transmitter in operation and walk up and down Great Portland-street with the receiver in my hand, with the telephone to the ear.

"The sounds seemed to slightly increase for a distance of 60 yards, then gradually diminish, until at 500 yards I could no longer with certainty hear the transmitted signals. What struck me as remarkable was that, opposite certain houses, I could hear better, whilst at others the signals could hardly be perceived. Hertz's discovery of nodal points in reflected waves (in 1887–9) has explained to me what was then considered a mystery.

"At Mr. A. Stroh's telegraph instrument manufactory, Mr. Stroh and myself could hear perfectly the currents transmitted from the third story to the basement, but I could not detect clear signals at my residence about a mile distant. The innumerable gas and water pipes intervening seemed to absorb or weaken too much the feeble transmitted extra currents from a small coil.

"The President of the Royal Society, Mr. Spottiswoode, together with the two hon. secretaries, Prof. Huxley and Prof. G. Stokes, called upon me on February 20, 1880, to see my experiments upen aërial transmission of signals. The experiments shown were most successful, and at first they seemed astonished at the results, but towards the close of three hours' experiments Prof. Stokes said, 'that all the results could be explained by known electromagnetic induction effects, and therefore he could not accept my view of actual aërial electric waves unknown up to that time, but thought I had quite enough original matter to form a Paper on the subject to be read at the Royal Society.'

"I was so discouraged at being unable to convince them of the truth of these aërial electric waves, that I actually refused to write a Paper on the subject, until I was better prepared to demonstrate the existence of these waves; and I continued my experiments for some years, in hopes of arriving at a perfect scientific demonstration of the existence of aërial electric waves, produced by a spark from the extra currents in coils, or from frictional electricity or secondary coils. The triumphant demonstration of these waves was reserved to Prof. Hertz, who by his masterly researches upon the subject in 1887–9 completely demonstrating not only their existence but their identity with ordinary light, in having the power of being reflected and refracted, &c., with nodal points, by means of which the length of the waves could be measured. Hertz experiments were far more conclusive than mine, although he used a much less effective receiver than the microphone or coherer.

"I then felt it was now too late to bring forward my previous experiments, and through not publishing my results, and means employed, I have been forced to see others remake the discoveries I had previously made as to the sensitiveness of the microphonic contact, and its useful employment as a receiver for electric aërial waves. Amongst the earliest workers in the field of aërial transmission I would draw attention to the experiments of Prof. Henry, who describes in his work, published by the Smithsonian Institute, Washington, D.C., U.S.A., Vol. I., p. 203 (date unknown, probably about 1850), that he magnetised a needle in a coil at 30ft. distance, and magnetised a needle by a discharge of lightning at eight miles distance.

"Marconi has lately demonstrated that by the use of the Hertzian waves and Branly's coherer he has been enabled to transmit and receive aërial electric waves to a greater distance than previously ever dreamed of by the numerous discoverers and inventors who have worked silently in this field. His efforts at demonstration merit the success he has received; and if (as I have lately read) he has discovered the means of concentrating these waves on a single point desired without diminishing its power, then the world will be right in placing his name on the highest pinnacle, in relation to aërial electric telegraphy.—Yours, &c., D. E. HUGHES.

J. J. Fahie, Esq., Claremont-hill,
St. Helier's, Jersey.

MAGNETISM.*

BY PROF. J. A. EWING.

(Concluded from page 21.)

A few incidental applications of magnetism to engineering purposes remain to be briefly mentioned. The attraction across a surface of division between two parts of a magnetic circuit, originally investigated by Joule in 1838, is made use of in the workshops in a variety of ways. Magnetic crane-hooks are employed to lay hold of and lift heavy plates. Drills and other tools are attached by magnetic attraction to the piece on which they are to work. Magnetic clutches serve to connect and disconnect lines of shafting. Magnetic brakes have been applied to the wheels of vehicles. In all these cases the force which is taken advantage of is due to magnetisation; it comes and goes with the making and breaking of the magnetising current, and it may readily be made to amount to nearly 200lb. per sq. in.

Thermo-magnetic engines have been devised to perform directly the conversion of heat into work. A piece of iron heated to bright redness (say 780°C.) loses nearly all its capacity for magnetic induction and ceases to be attracted by a magnet. It may therefore be withdrawn from the neighbourhood of a magnet pole without expenditure of work; but once the iron is cooled the magnet resumes its attraction. Hence, by heating the iron when it is in a strong field, then removing it while hot to a place where the field is weaker, then cooling it till the magnetic action reasserts itself and then allowing it to return, we take it through a cycle in which mechanical work is done by it, work which may be applied to a useful purpose by appropriate means. The energy to do the work comes from heat, more heat being absorbed in the heating of the iron than is given out in the cooling. But though it is easy to make a working model which will illustrate the principle of this action, the task of making an engine which will carry it out efficiently on a practical scale has not been accomplished, nor is it in the least likely of accomplishment. A model is shown on the table in which the working substance is nickel, which loses its magnetic quality at a lower temperature than does iron, and by alternately heating and cooling the

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* "James Forrest" Lecture, delivered at the Institution of Civil Engineers, April 20.